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(71) Applicant
Imperial Chemical Industries Limited, Imperial Chemical House, Millbank, London SW1P 3JF
(72) Inventor
Peter Henry Harris
(74) Agent
Hulse & Co., Cavendish Buildings, West Street, Sheffield S1 1ZZ

(54) Method and Apparatus for Measuring the Optical Retardation of Synthetic Filaments or Film

(57) A method for measuring the optical retardation of synthetic filament or film (Q) comprises passing polarised light with a continuously uniformly rotating plane of polarisation through an optical compensator (O), through the filament or film (Q), through a dichroic filter (R) with its plane of polarisation at 45° to the principal axes of the filament or film, and then to a photodetector (S), amplifying the signal from the photodetector (S), filtering out any noise from the amplified signal, feeding the signal to an indicator (U), and adjusting the compensator (O) until the reading on the indicator (U) is a maximum or minimum. The apparatus consists of a light source (K), a rotatable dichroic filter (L) and motor (M), a compensator (O), e.g. of the "Soleil" type, locating means for the filament or film (Q), a non-rotatable dichroic filter (R), a photodetector (S), an amplifier and filter (T) and an indicator (U), all of which is incorporated in a hand-held device Fig. 3.

An alternative method and apparatus, Fig. 1 has a different arrangement of components but is sensitive to any polarised ambient light and light scatter in the sample.

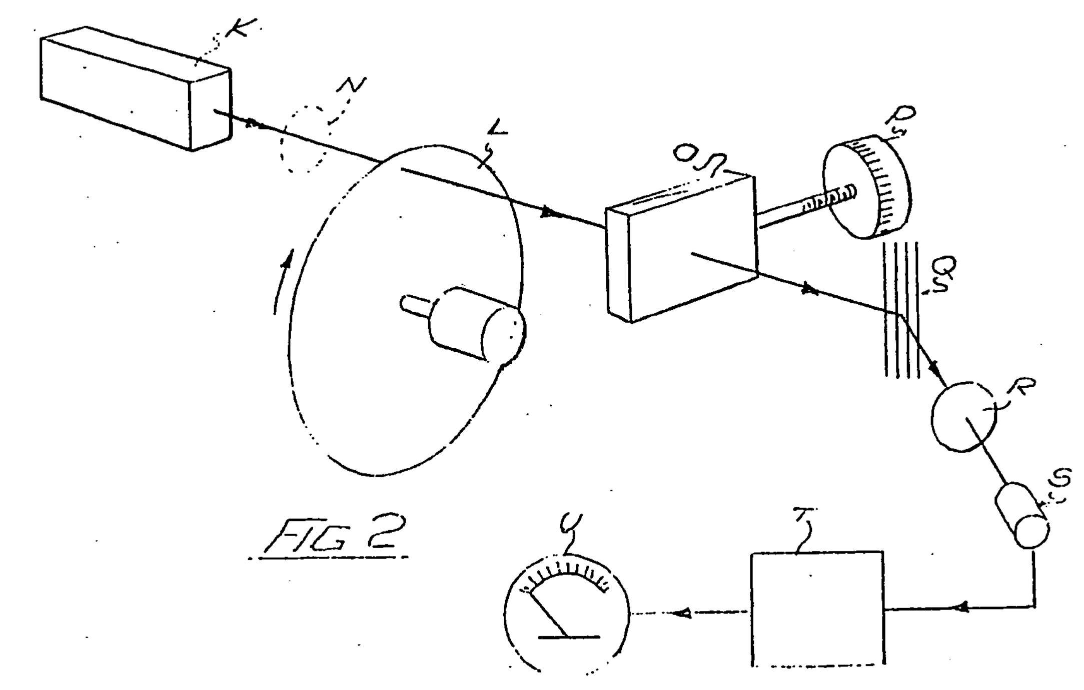

FIG 2

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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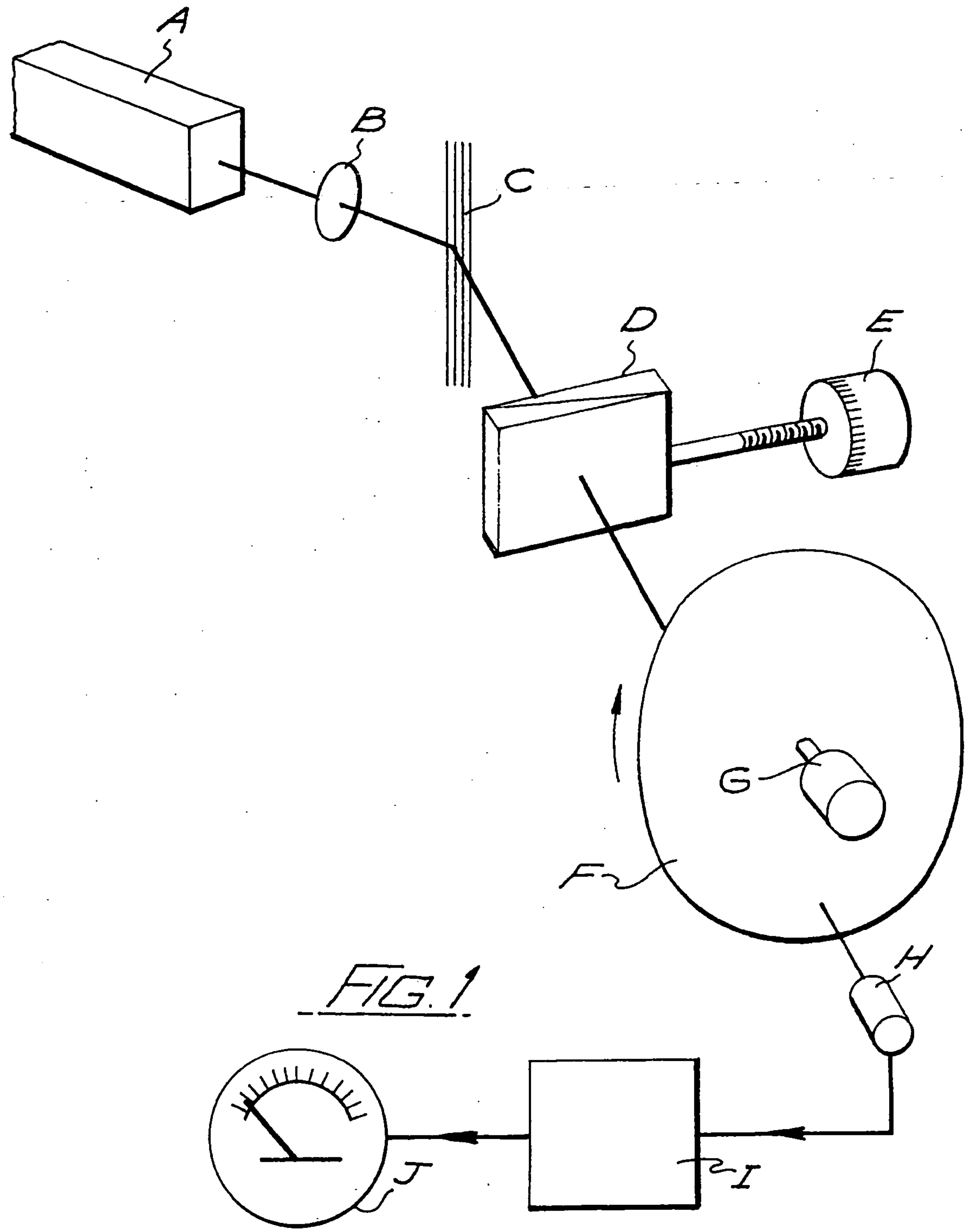

FIG. 1

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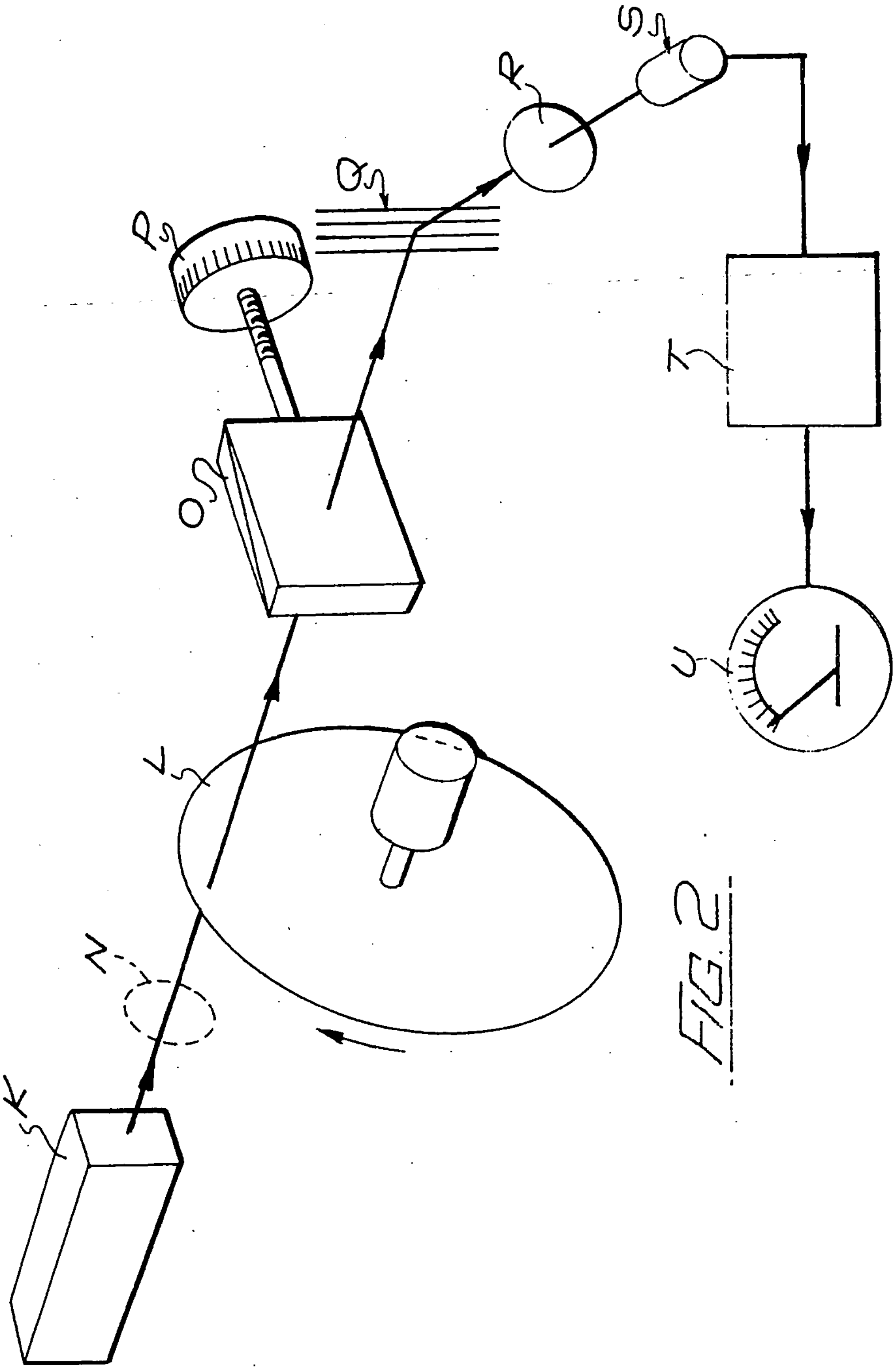

FIG. 2

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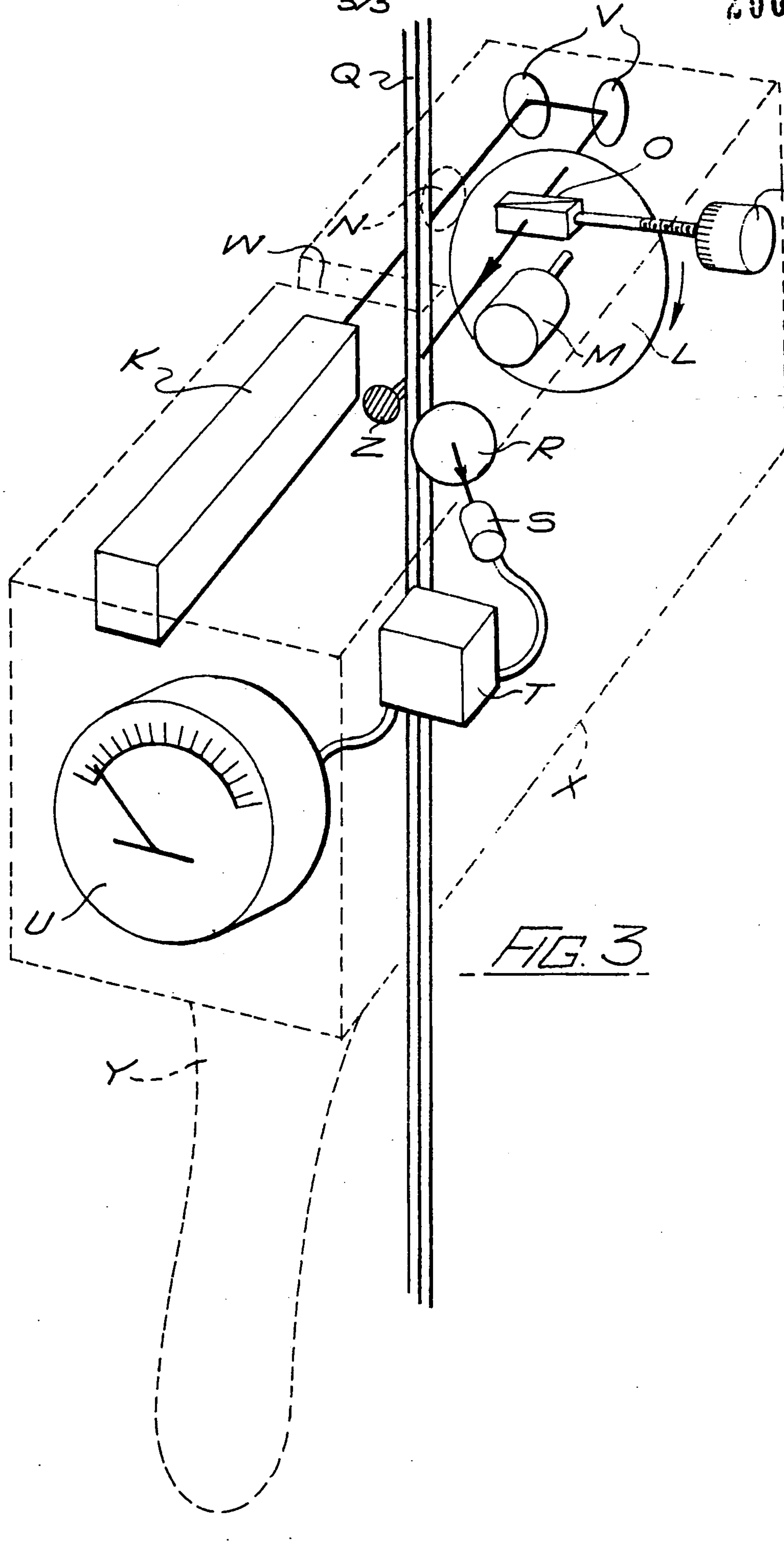

FIG. 3

SPECIFICATION

Method and Apparatus for Measuring the Optical Retardation of Synthetic Filaments or Film

This invention relates to methods and apparatus for measuring the optical retardation of synthetic filaments in an advancing threadline or of an advancing synthetic film. For example, work has been carried out in continuously measuring the optical retardation of a synthetic polyester filament yarn formed by melt spinning and producing a signal dependent on the optical retardation, which signal is used to control one or more associated process parameters such as the speed at which the yarn is wound up in dependent on the birefrigenece of the wound filaments.

It has been proposed to pass continuously variable polarised light through the filaments or film, monitoring the state of polarisation of light refracted by the filaments or film, and measuring any relative change that occurs in that state. Preferably, two coherent orthogonally plane polarised monochromatic light beams which are collinear and with slightly different light frequencies are allowed to fall on a yarn in the form of a single filament ribbon, and light deviated by refraction at the filament then passes through a dichroic filter with its plane of polarisation at 45° to the planes of polarisation of the two beams, and on to a photodetector the electrical signal from which is thus a beat frequency equal to the difference between the two light frequencies. A reference beat frequency is obtained from unrefracted light and the phase difference between the two beat frequency signals (which phase difference is directly related to the retardation of the light passing through the filament ribbon) is measured by an electronic phasemeter from which an analogue voltage is obtained to operate a chart recorder and/or provide a feedback signal for control purposes.

The need for an electronic phasemeter renders the apparatus required rather cumbersome and heavy so that its use is generally confined to one production line.

It is also known to measure birefringence by passing through a sample light plane polarised by a first polariser at 45° to the principal axes of the sample, then through a compensator which can be adjusted to introduce an equal and opposite phase retardation to that of the sample, the beam from the compensator then being plane polarised in the same plane as in the incident light, and this condition being detected by a second polariser crossed with the first polariser, minimum transmission by the second filter then resulting from a correct setting of the compensator or a setting removed from it by an integral number of wavelengths.

While a hand-held device operating on this principle is feasible, the judging of the minimum brightness is difficult in production situations due to the intensity of normal lighting in the manufacturing areas and/or due to light scatter due to inclusion of delustrants in the filament or film.

The object of the present invention is to provide methods and apparatus for measuring birefringence and readily adaptable to handheld devices capable of giving clear readings.

According to one aspect of the present invention, a method for measuring the optical retardation of synthetic filament or film comprises passing unpolarised light through a dichroic filter and through the filament or film, with the plane of polarisation of the dichroic filter at 45° to the principal optic axes of the filament or film, then through an optical compensator, passing the light beam from the compensator through a dichroic filter rotating continuously and uniformly in its own plane to a photodetector, amplifying the signal from the photodetector, filtering out any noise from the amplified signal, feeding the signal to an indicator, and adjusting the compensator until the reading on the indicator is a maximum or minimum.

The apparatus, consisting of a light source, a dichroic filter, locating means for the filament or film, a compensator, a rotatable dichroic filter and motor, a photodetector, an amplifier, a filter and an indicator, can be readily incorporated in a hand-held device. A colour filter may be provided between the light source and the dichroic filter. The location means for the filament or film may be interchanged with the compensator.

This method and apparatus is, however, sensitive to any polarised ambient light and light scatter due to the inclusion of delustrants in the filaments or film.

Therefore, in accordance with another aspect of the invention, a method for measuring the optical retardation of synthetic filament or film comprises passing polarised light with a continuously uniformly rotating plane of polarisation, through an optical compensator, through the filament or film, through a dichroic filter with its plane of polarisation at 45° to the principal axes of the filament or film, and then to a photodetector, amplifying the signal from the photodetector, filtering out any noise from the amplified signal, feeding the signal to an indicator, and adjusting the compensator until the reading on the indicator is a maximum or minimum.

The apparatus consists of the same integers as above arranged in a different order, i.e., a light source, a rotatable dichroic filter and motor, a compensator, locating means for the filament or film, a non-rotatable dichroic filter, a photodetector, an amplifier, a filter and an indicator, and again can be readily incorporated in a hand-held device. A colour filter may be provided between the dichroic filter and the photodetector. Again, the location means for the filament or film may be interchanged with the compensator.

Embodiments of the invention will now be described, by way of example, only, with

reference to the accompanying drawings, in which:—

Figure 1 is a diagrammatic illustration of one form of apparatus in accordance with the first aspect of the invention;

Figure 2 is a diagrammatic illustration of one form of apparatus in accordance with the second aspect of the invention; and

Figure 3 is a diagrammatic illustration of a form of hand-held device incorporating the apparatus of Figure 2.

In Figure 1 unpolarised light from a source A passes through a dichroic filter B and through a threadline C, with the plane of polarisation of the dichroic filter at 45° to the principal optic axes of the filaments in the threadline. Light deviated by the filaments then passes through an optical compensator D, e.g. of the "Soleil" type with a calibrated knob E for effecting linear adjustment of the compensator. The light beam from the compensator passes through a dichroic filter F, which is rotated continuously and uniformly in its own plane by a motor G, and to a photodetector H. The resulting signal is amplified by an amplifier and electronic filter I, the output of which is indicated by a meter J. The setting of the compensator D is adjusted until the reading on the meter I is a maximum (or a minimum).

A colour filter (not shown) may be provided—if need be—between the light source A and the dichroic filter B, and location means for the filaments C may be interchanged with the compensator. This apparatus could be readily incorporated in a hand-held device, but because this method and apparatus is, however, sensitive to any polarised ambient light and light scatter due to the inclusion of delustrants (e.g., TiO_2) in the filaments, it is preferable to incorporate the apparatus of Figure 2 in a hand-held device as shown in Figure 3.

In Figure 2, polarised light from a light source K is directed in a parallel light beam through a Polaroid (registered Trade Mark) disc L continuously and uniformly rotated by a motor M. If the light source K is a laser producing polarised light then a quarter wave plate N is inserted to produce circularly polarised light before the rotating Polaroid disc L. A compensator O with calibrated adjustment knob P is disposed in the path of the beam from the disc L to a threadline Q. A fraction of the light deviated by the filaments passes through a fixed Polaroid disc R oriented with its plane of polarisation at 45° to the filament axes and is collected by a photodetector S. The signal from the photodetector is again amplified by an amplifier and electronic filter T, the output of which is indicated by a meter U. The setting of the compensator O is adjusted until the reading on the meter U is a maximum (or a minimum).

A practical embodiment of the apparatus of Figure 2 is shown in Figure 3 with like parts denoted by like reference letters. The beam from the source K is bent back parallel to itself by means of two plane reflectors V to pass through the Polaroid disc L and the compensator O to reach the filaments Q, about which is fitted a slot W in a case X containing the apparatus and provided with a handle Y. A beam stop Z is provided to intercept any light which misses the filaments Q. The slot could, alternatively, be fitted about a film to enable this hand-held device to be used to measure the optical retardation of the film, in this instance the light transmitted through the film in line would be measured.

Claims

1. A method for measuring the optical retardation of synthetic filament or film comprising passing unpolarised light through a dichroic filter and through the filament or film, with the plane of polarisation of the dichroic filter at 45° to the principal optic axes of the filament or film, then through an optical compensator, passing the light beam from the compensator through a dichroic filter rotating continuously and uniformly in its own plane to a photodetector, amplifying the signal from the photodetector, filtering out any noise from the amplified signal, feeding the signal to an indicator, and adjusting the compensator until the reading on the indicator is a maximum or minimum.

2. Apparatus for carrying out the method of Claim 1 and consisting of a light source, a dichroic filter, locating means for the filament or film, a compensator, a rotatable dichroic filter and motor, a photodetector, an amplifier, a filter and an indicator.

3. Apparatus as in Claim 2 incorporated in a hand-held device.

4. Apparatus as in Claim 2 or Claim 3 wherein a colour filter is provided between the light source and the dichroic filter.

5. Apparatus as in any one of Claims 2 to 4, wherein the location means for the filament or film is interchanged with the compensator.

6. A method for measuring the optical retardation of synthetic filament or film comprising passing polarised light with a continuously uniformly rotating plane of polarisation, through an optical compensator, through the filament or film, through a dichroic filter with its plane of polarisation at 45° to the principal axes of the filament or film, and then to a photodetector, amplifying the signal from the photodetector, filtering out any noise from the amplified signal, feeding the signal to an indicator, and adjusting the compensator until the reading on the indicator is a maximum or minimum.

7. Apparatus for carrying out the method of Claim 6 and consisting of a light source, a rotatable dichroic filter and motor, a compensator, locating means for the filament or film, a non-rotatable dichroic filter, a photodetector, an amplifier, a filter and an indicator.

8. Apparatus as in Claim 7 incorporated in a hand-held device.

9. Apparatus as in Claim 7 or Claim 8, wherein a colour filter is provided between the dichroic filter and the photodetector.

10. Apparatus as in any one of Claims 7 to 9, wherein the location means for the filament or film is interchanged with the compensator.

11. A method for measuring the optical retardation of synthetic filament or film substantially as hereinbefore described with reference to Figure 1 or Figure 2 of the accompanying drawings.

12. Apparatus for measuing the optical retardation of synthetic filament or film and substantially as hereinbefore described with reference to any one of Figures 1 to 3 of the accompanying drawings.

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